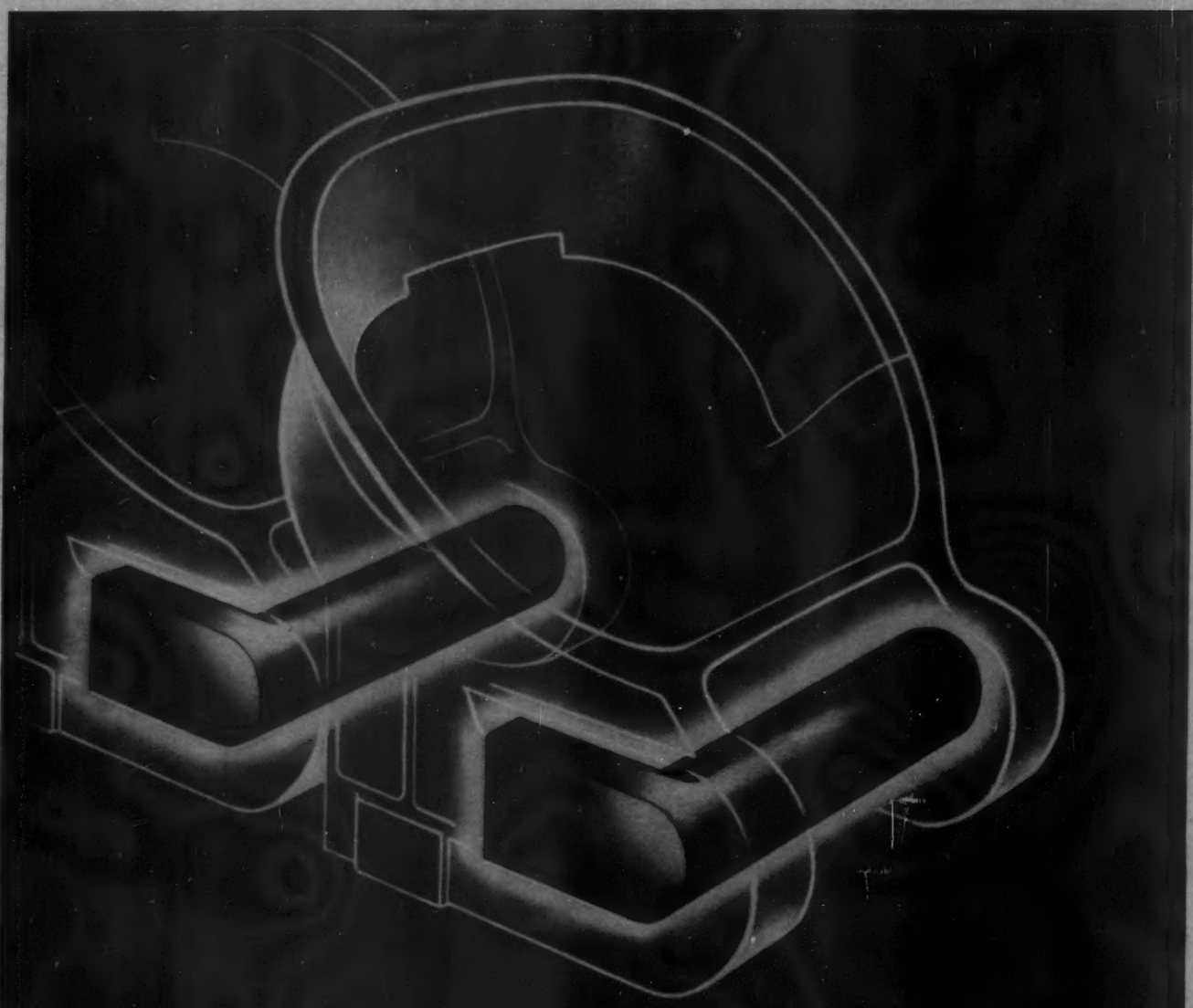
TECH ENGINEERING NEWS

FEBRUARY · 1942



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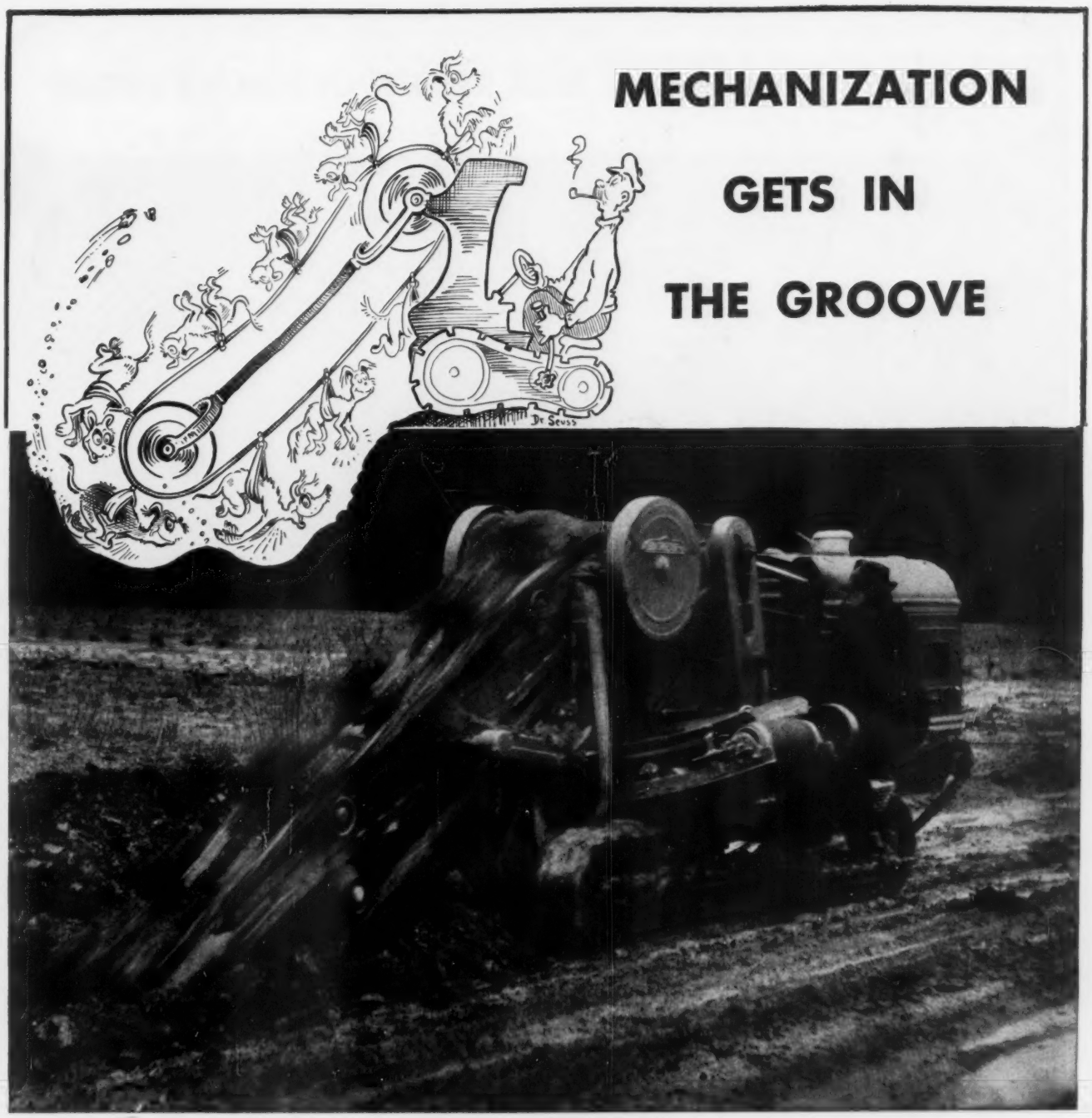

● Our "guest artist," Dr. Seuss, has caricatured the remarkable machine which digs ditches for pipe lines or for Army trenches.

This machine is shown operating through ten inches of frost. In it, 67 New Departure ball bearings, many of them self-sealed to keep dirt out and lubricant in, assure long life, maximum power for digging and extremely low maintenance.

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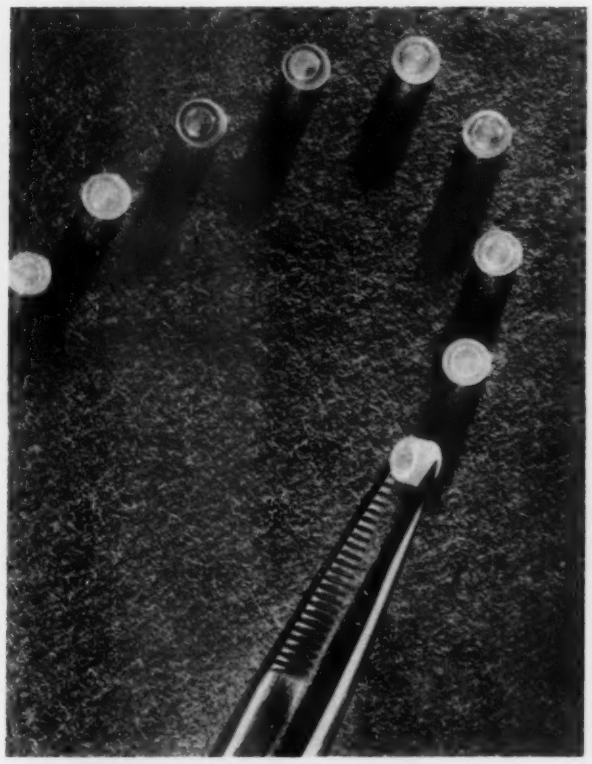

VOLUME XXIII

NUMBER 1

OUR COVER THIS MONTH

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PHOSPHORUS AND THE PHOSPHATES

PHOSPHORUS, AGE-OLD TOOL OF THE ALCHEMIST, IS A WAR NECESSITY

By PAUL LOGUE
MONSANTO CHEMICAL COMPANY

PHOSPHORUS is an element, one of the ninety-two into which all matter is organized. In elemental form it is a yellowish, waxy solid, although under certain conditions it takes on other forms. Phosphorus was first prepared in the latter part of the seventeenth century but more than a hundred years passed before its nature as an element was demonstrated. Because the substance glowed with a steady cold light, the early investigators called it phosphorus mirabilis — marvelous bearer of light.

Phosphorus is extremely active. In air it burns spontaneously, combining with oxygen in an intense flame. It combines directly with many other elements and with hydrogen and oxygen it forms a series of acids. These acids, in turn, give rise to hundreds of salts. The usefulness of the phosphorus compounds in industry derive in large part from their multiplicity and versatility.

Phosphorus is not rare since nearly all rock contains it, and it is twelfth in the list of those elements that comprise the crust of the earth and is considered the most widely subdivided of all. Despite this wide distribution, it never occurs naturally in the elemental form but always in combination with other elements. Only from deposits where concentration is fairly high is it possible to extract the element on an economical basis. Deposits of so-called phosphate rock or matrix, however, are found on every continent. In the United States there are sizeable deposits in Florida, Tennessee, Idaho, Arkansas and Montana. The Tennessee areas, however, account for the principal domestic production of elemental phosphorus from which high-grade phosphoric acid and the phosphates of commerce are made.

Compounds of phosphorus are essential to life. The mineral component of the bones and teeth, for instance, is largely tricalcium phosphate. Phosphorus is also present in virtually every other part of the body, including the blood stream. The body of a grown man contains approximately one and one-half pounds of phosphorus. Plant growth requires phosphorus, and most foods contain appreciable amounts of the element; one hundred pounds of corn, for instance, contains the equivalent of one pound of the element.

apping slag
om electric furnace

The phosphates have been articles of commerce for more than a hundred years. As early as 1800 dicalcium phosphate was prescribed and used as a medicinal. By the middle of the last century monocalcium phosphate had been developed as an acid leavening agent in baking powders. Since the turn of the century the sodium phosphates have come into increasing use as detergents and cleansers. Naturally occurring phosphates for many years have been used as fertilizers. On a tonnage basis, these relatively low-grade products still represent the most important single use of phosphorus compounds.

The rapid strides in the manufacture of phosphorus and its derivatives have immeasurably broadened the usefulness of these chemicals. The production of virtually pure elemental phosphorus and the resultant availability of pure phosphoric acid and phosphates has given a tremendous impetus to the expansion of uses. The tonnage consumption of high-grade phosphates, therefore, continues to grow constantly.

Although phosphorus forms a number of different acids, the most important is ortho-phosphoric, from which the phosphates are derived. This compound is produced commercially in pure form from elemental phosphorus in two steps which involve the burning of the element in air to form the pentoxide and the subsequent hydration of this compound to the acid. These two steps are carried out continuously and successively with the latter accomplished by a water spray in the stream of phosphorus pentoxide vapor as it leaves the burner. The reactions proceed: $2P+5O \rightarrow P_2O_5$; $P_2O_5+3H_2O \rightarrow 2H_3PO_4$.

The manufacture of high-grade phosphoric acid depends on the production of elemental phosphorus. This is accomplished through use of an electro-thermal process employing electric furnaces. An important contribution has been made to the natural resources of this country through the perfection and industrial application of this process, since it permits the use of relatively low grade raw material which would be uneconomic under older methods.

The first step in the electric furnace process is the mining of phosphate-bearing earth, designated as "rock." The operation involves the handling of large tonnages of a heavy, bulky raw material. Earth digging and handling equipment of tremendous capacity

is utilized, including electric drag lines and twelve-ton trailer-trucks.

The ore consists of a gravelly earth deposited from three to fifty feet beneath the surface and buried between ridges of limestone. The matrix varies in phosphate content and the two grades, low and medium, are prepared for processing in different ways.

The higher grade matrix is run through a crusher to reduce the larger particles and stored for processing. The lower grade material is concentrated to bring up its average phosphorus content. Concentration is carried out by a system of washers, classifiers and thickeners, which removes some of the clay and other fine material. The result is a concentrate which approximates the higher grade matrix in phosphate content.

Crushed higher grade matrix and washed concentrate are stored in roofed-over enclosures from which they are fed to the sintering operation. Sintering is a key operation in the process since it makes possible the use of a relatively low grade and finely divided raw material in electric furnace production by forming the gravelly matrix into porous, uniformly sized particles ready for mixing into the furnace charge.

The charge for the furnace consists of a carefully measured mixture of sinter, coke and in some cases silica sand. The sinter is, of course, the source of phosphorus; the coke provides carbon as a reducing agent; and the silica is added under certain conditions to insure slagging of undesirable components.

In the intense heat of the arc formed between the electrodes the stock melts and the carbon removes the oxygen from the phosphatic component of the charge, freeing elemental phosphorus as a vapor. This, mixed with carbon monoxide, passes off and through a hot water spray which condenses it. The condenser phosphorus is collected under water in a sump while carbon monoxide is carried away for use as a fuel in sintering and other processes.

Uses

Elemental phosphorus itself, although of paramount value as the source of phosphoric acid and the phosphates, is an important industrial material in its own right. Now of prime importance are the uses of phosphorus in incendiary bombs and other missiles of fire warfare. Here, the ready-oxidizing property of phosphorus, which is so completely tamed in phosphate compounds, is integral to the function of the device.

Metals

Phosphorus and its compounds make valuable contributions in present-day metal industries. The element itself is an important alloying agent in steels and in phosphor bronzes.

In addition to phosphorus itself, phosphoric acid and the sodium phosphates are familiar tools in the metal industries. The acid is important in metal rust-proofing treatments. Modern automobiles owe their permanent good appearance in a considerable degree to such processes. In industrial metal cleaning, both trisodium phosphate and tetrasodium pyrophosphate are used for their highly effective detergency.

Water Treating

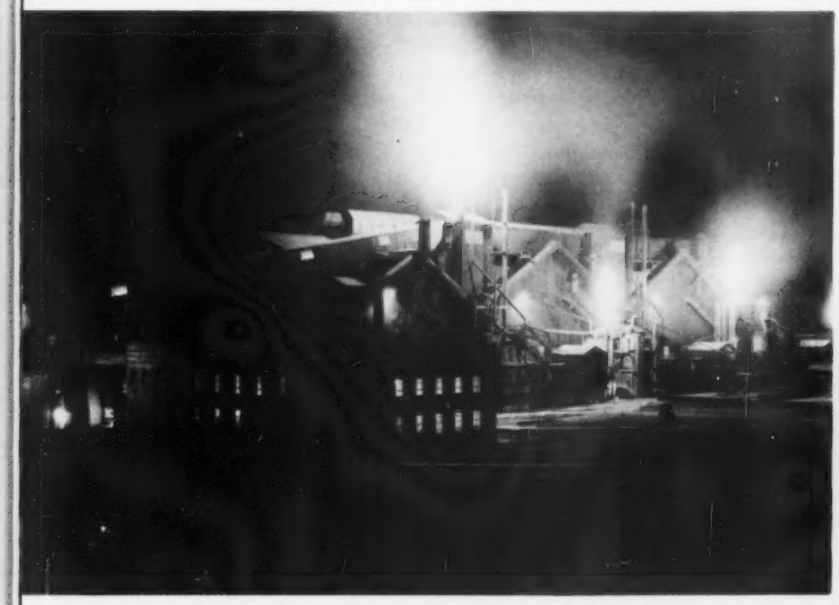
Sodium phosphates are effective water softeners. Water is hard when mineral salts, principally of calcium and magnesium, are present. When water containing these salts is brought into contact with soaps, insoluble calcium and magnesium soaps are formed which settle out, sharply reducing the efficiency of the soap and giving rise to scum formation.

When untreated hard water is used in steam boilers, the high temperatures convert the soluble mineral salts to insoluble precipitates which build up on the boiler surfaces in the form of scale. Scale is a very poor heat conductor and its accumulation cuts boiler efficiency. By treating boiler water with sodium phosphates, scale formation is prevented.

Textiles

The textile industry constitutes a broad market for virtually all the sodium phosphates. Trisodium phosphate is used here, as in other industries, because of its high detergency. The use of sodium phosphates in textile processing, however, is not based alone on their detergent action. Tetrasodium pyrophosphate, for instance, is used in bleach baths, particularly with hydrogen peroxide, with which it has a modifying effect tending to prevent too drastic action of the bleach. The same salt is also used in dye baths, in conjunction with dyestuffs which tend to deposit unabsorbed particles on the fabric and cause (*Continued on page 14*)

A night view of the Monsanto, Tennessee, plant



Mining phosphate-bearing matrix

Geo. Breon Co.

Sterilamp under hood insures protection of ampuling from air currents that might carry bacteria. Plate glass shields operator's eyes.

BENEFICENT KILLER

STERILIZATION, LIKE WAR, MUST MEAN DEATH TO THE ENEMY

By CLYDE C. SNYDER, JR. '45

PERHAPS of all the stirring enterprises of modern research, none holds more promise to mankind than the current patient experimentation with ultraviolet radiation as a killer of bacteria and a paralyzer of viruses.

Progress has been startling. Within five years bactericidal ultraviolet has changed from a little-understood scientific quantity to an important aid to public health. It now sanitizes foodstuffs and beverages during and after manufacture. It protects restaurant patrons from disease that might be communicable through unclean glassware or silver. It has enabled meat-packers to lop days off the time required for tenderizing beef, so that tender meat is now available to millions of people who never before could afford it. Even face cream now passes through the cleansing radiation before it goes to market.

Medical investigators, too, have found convincing evidence of the efficacy of ultraviolet for controlling contagion and post-operative infections in hospitals, and to some extent for hastening the healing of wounds.

They Float Through the Air

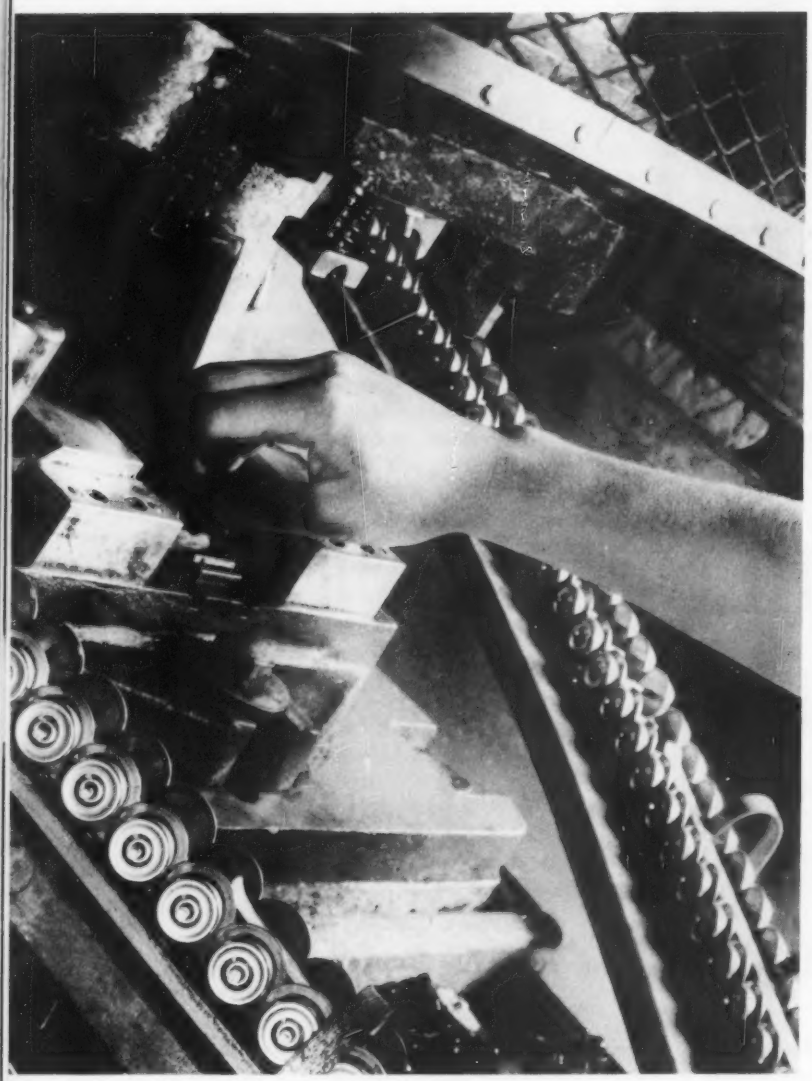
Twelve years ago two eminent scientists in cities three hundred fifty miles apart almost simultaneously hit upon the idea of irradiating the air with ultraviolet to suppress infection. A professor at the University of Pennsylvania began to study its possibilities by debunking an accepted theory that bacteria expelled by coughing or sneezing merely fall to the floor, there to die.

As a corollary, physicians believed that the only measure necessary to prevent spread of communicable disease was to keep an infected person "out of coughing range" of others. University of Pennsylvania people dissented. They believed that such bacteria are merely nuclei of water droplets of varying size. They began to experiment. Large droplets, they found, do fall slowly to the floor, but small ones — some almost microscopic — float, and are diffused over wide areas by currents of air! Further, some of these air-borne pathogens survive forty-eight hours or more, which means that you might conceivably get an infectious disease today from a germ sneezed into the air day before yesterday by a person across the street.

Since air was revealed as a disease-carrying medium, the obvious way of controlling contagion seemed to be to spray the air with some germicidal solution. The investigators in Philadelphia chose ultraviolet as the "solution," and have for several years been studying the effect of air irradiation upon the incidence of contagion in groups of susceptible people. They are not yet ready to draw conclusions, but recently reported before the American Association for the Advancement of Science that their experiments indicate the possibility of controlling children's contagious diseases by irradiation with ultraviolet to reduce the bacterial count in ventilating air in schools.

Sneak Killers Ousted from Surgeries

While the University of Pennsylvania was working quietly on the new theory of air-borne contagion, Dr. Deryl Hart, of Duke University, was laboring on the same problem, but with a view toward its application in surgery. Despite the most (*Continued on page 20*)



LILLIPUTIAN LOCOMOTIVES

TRAINS ARE NOW BEING PRODUCED ON ASSEMBLY LINES— HUNDREDS A DAY

By
THE LIONEL CORPORATION

FREIGHT cars on a conveyor belt, moving by the hundreds down the assembly line of a roaring factory—it is not orthodox. Straight-line production is the darling of the automobile trade, not the railroad supply industry.

But straight-line it is, and freight cars they are. Box cars and refrigerator cars, gondola cars and hoppers, they flash the names and heralds of the New York Central, the B. & O., the Pennsylvania, half a dozen others of the outstanding railroads of the United States. And down to the last detail, each one is precisely what it purports to be — except that these hundreds and thousands of cars are but eleven inches long, and less than four inches high. They are, indeed, scale model cars for the four million boys, and the hundred thousand grown men, who form the backbone of the miniature railroading hobby in the United States and Canada. And the factory producing them is the plant of the Lionel Corporation, manufacturers in the past forty-two years of more than half the electric trains sold in this country.

Each of the cars is an accurate reproduction of its prototype, precision-made to the scale of a quarter-of-inch to the foot. Each is equipped with automatic couplers, and with trucks that are not only equalized but sprung. Each car, of course, has two trucks, and each truck in turn has four wheels. An equalized truck is one so constructed that each wheel separately is free to follow the ups and downs of the rail; thus the irregularities of track are overcome. And a truck is said to be sprung if it is equipped with springs on which the load is carried.

So the men who work on either side of the assembly line have a job to do that calls for skill and care. But still the cars pour forth, thanks to a highly developed factory organization.

The Lionel plant, vast and complicated, is housed in a single brick structure covering seven acres at Irvington, N. J., ten miles west of New York City. At one end of this structure are four assembly lines, where one by one a total of four or five hundred different items of manufacture arrive at the final stage of mass production. At the other end are the engineering rooms, where a staff of twenty experts, including four electrical and several mechanical engineers, are at work the whole year round. And in between these two extremes,

manned by more than a thousand employees, is a maze of manufacturing and finishing equipment — die-casting machines, batteries of plastic mold ejectors, automatic metal stamping presses, gear cutters, armature winders, plating and oxidizing equipment, enamel dipping conveyors, enamel spraying booths, dozens of other pieces of machinery. Biggest of all is a tremendous baking tunnel through which all painted parts are conveyed under intense heat to acquire a glistening chip-proof finish.

The engineering room is responsible for the beginning and the end of the manufacturing process. Here, for example, the blueprints of the New York Central's Hudson-type locomotive were received and "scaled down" for the model makers, who produced by hand a plaster mold, filled it with molten metal and thus obtained a first casting of what was to become the famous model of a famous prototype. Two years' work and $60,000 were spent in the final completion of that model, in which every last rivet in the prototype was reproduced.

And when that locomotive was finally placed in mass production, it rolled off the assembly line directly upon a track where it was once more in the hands of the engineers, who supervised the test runs. Every piece of electric equipment which the factory turns out is tested in this way, for starting and smooth running qualities, and for its response to each turn of the speed controls.

The manufacture of highly detailed scale models — reproductions of handsome American locomotives and cars — is a comparatively recent venture in toy train production, dating back only to the early 1930's when model railroading came in with a rush as the hobby of thousands of grown men. But for forty-two years Lionel has manufactured sturdy and colorful trains for boys, and this trade continues, though little by little these toy trains have been brought closer and closer to scale dimensions.

Developments in miniature electric trains which have come from Lionel's engineering department include an electrically operated, built-in railroad whistle which can be sounded by remote control from the locomotive whether it is moving or standing still. Track on which the trains operate furnish the source of current for running the locomotive motor. In order to operate the whistle motor at will, without interfering with the locomotive motor and without introducing a new electrical circuit, DC was superimposed on the AC circuit and a DC relay was used to actuate the whistle mechanism. As it was necessary only to introduce less than one volt DC to actuate the relay, it was possible to employ an inexpensive rectifier.

Another interesting Lionel development may be found in low voltage step-down transformers, which are used for the operation of all trains. The problem was to control the speed of trains from a slow crawl to a fast clip by gradual degrees and without the necessity of a rheostat and without breaking the circuit, which would reverse the direction of the motor. The solution was found by winding the secondary coil in a single layer to be engaged by a rolling contact. Copper ribbon wound on edge was used instead of wire in order to obtain sufficient turns. This made it possible to use four contacts on the secondary windings, giving outlets for four circuits which could be controlled independently. A thermostatic circuit breaker was also built into the step-down transformer which Lionel called a Trainmaster.

The government became aware of the unusual manufacturing facilities at the Lionel plant more than a year ago and for many months Lionel has been busy turning out quantities of navy instruments such as binnacles, compasses and alidades. The Lionel tool room is well equipped for precision work, with jig-borers used for requirements established at 1/10,000-inch tolerances. Because Lionel train parts must be made interchangeable and all fittings must be eliminated, tolerances of 1/2000 inch are usually called for.

The Lionel plant is highly versatile, employing stamping machines, die-casting equipment, plastic molding and woodworking. There are hundreds of power presses, many of them large, automatic and fast. They range from one ram up to six rams and from a slow of 20 strokes per minute up to a speed of 1,000. In the die-casting department, newly perfected zinc base alloys are used, their purity overcoming deterioration. Color finishes are applied over Bonderized or chemically treated surfaces to obtain the greatest adhesion of synthetic resin enamels. Normally, in peace years, the plating department finishes streamline trains and small parts in chromium, nickel, cadmium, copper, zinc and tin. Some metal parts are oxidized where a dull black color is desired.

And thousands upon thousands of these toy trains pour forth from the assembly lines. Punched and pummeled into shape in tremendous stamping presses, the car bodies are enameled, the window-frames electroplated in chrome, brass or uickel. The enamel work is passed through the baking tunnel. And the final runs on testing track are carried out under the supervision of engineers.

A single locomotive may cost as much as $75 if

What tank-car shortage?

it is a scale job; but the same factory also turns out a whole train which retails for less than $10, including track. And between these two extremes, other trains are produced to sell at graduated prices all the way up to $100 each. All pass through the same hands on the testing track, all receive the same careful attention, and the price differences are accounted for, in slight measure by the amounts of material used, but almost entirely by the number and complication of the manufacturing processes involved.

The "season" means a great deal to Lionel. It opens every year early in November. The real rush is concentrated between Thanksgiving Day and Christmas Eve; in these four weeks alone 85 per cent of the company's trains and accessories are sold.

Time was when the company went on a long vacation after that, but the swift rise of model railroading in the past ten years with its new problems and incessant demands has changed that picture. Now Lionel works the whole year round; and it works in preparation not only for each forthcoming Christmas, but in large measure also for the Christmas after that again. It is the surprising truth that work was begun a year ago last March on the various new items which go on sale for the first time in the coming 1942 season, at the end of this year.

Founded back at the very turn of the century when the electric battery was still new, the Lionel Company grew steadily for twenty years, and then in the post-war period, when the gas-mantle was popping out and millions of American homes were wired for electricity, a new and greater prosperity was followed by swift expansion. Batteries discarded, the trains drew their power from almost fool-proof transformers which were simply "plugged in" on the house circuit.

By 1930 there were 4,000,000 "Lionel families" in the United States and Canada. These were families in which at least one set of Lionel trains was owned — to be brought forth year after year at Christmas time, and to be added to every year. Many a large system begun by the father in his boyhood was now in the hands of the son in the generation that came later.

Model railroading came in with a great rush along about the middle thirties, and the spreading out of the Lionel interest in this direction was made without sacrificing the good will of so many in railroading itself.

This first came into widespread notice as the hobby of certain young and middle-aged men, largely engineering school graduates, a few years before the market crash of 1929. After the crash it spread with marked rapidity — became a new and salutary enthusiasm of tens of thousands of grown men. Today it is believed to be the hobby of no fewer than 100,000 men averaging 35 or 40 years of age. And almost from the start they demanded cars and locomotives of a sort unheard of before. What they wanted, on every score, was an exact scale-model of the real thing.

This new demand coincided at the beginning with an immensely wider popular interest in the streamlining of trains, and Lionel seized (*Continued on page 16*)

MILK-MADE MUSLIN

ONCE AGAIN INDUSTRY TURNS TO AGRICULTURE AS THE SOURCE OF A NEW MATERIAL

Finished "Aralac" fiber *Nat. Dairy Prod. Corp.*

By J. T. HARKER '43

IT is only in times of stress that there is much flurry connected with the commercial development of new synthetics. However, at a time such as the present, it is with a great deal of interest that each new possibility in the synthetic or "Ersatz" field is regarded. It is indigenous with the war economy of a nation that that nation be as nearly self-contained and independent as is humanly possible. It is with this thought in mind that we take a look at a new fiber made from the casein in milk. This new fiber is called "Aralac" and has been developed by the National Dairy Products Corporation.

This new fiber was first regarded as a possible outlet for the tremendous yearly skim milk surplus that this country has. This skim milk is left after butter fat is removed from the whole milk. It was formerly used principally for the feeding of live stock and the casein contained therein was, of course, not available for processing.

Casein has, of course, been used for a number of years in the paint, paper, and glue industries and recently its application in plastics has become much wider. In fact, the use of casein as a possible source of synthetic fiber was discovered in the latter part of the last century. However, at that time it was practically impossible to obtain the necessary quality of casein for that purpose. Because of that, development of this particular branch of the synthetics industry was to some extent neglected. Recently, however, through plants erected specifically for that purpose, it has been comparatively easy to get large quantities of either good skim milk or the pure casein itself. Consequently, this industry began to grow and the new fiber, while not wholly satisfactory at the outset for combination with all other fibers, grew through the application of this new product to the felt-fur hat industry. In fact, it grew so rapidly it is of some interest to note that in 1940 it was necessary to import some 22,000,000 pounds of casein from Argentina to meet the demands of the trade.

Even without the demands on the casein supply occasioned by this latest research in casein derivatives, the supply was sharply curtailed by the lend-lease activities of this government. It is necessary to have skim milk to produce casein and the United States began sending large quantities of powdered skim milk to Great Britain. However, with the new uses of casein as a fiber source, of a quality comparable with fur or wool, in sight after the cessation of the present conflict, many more plants are being set up to make casein from skim milk. There are enormous amounts of this skim milk potentially available, but the present plants are not located conveniently enough to sources of supply to tap even the reserves on hand. In fact, since the making of casein is basically a simple process, some attempt has been made to enable the farmers to manufacture casein on the farm, thereby obviating the necessity of transporting the bulky skim milk any great distance. If this could be done it would be practicably advantageous in view of the fact that from each hundred pounds of skim milk only three pounds of casein are obtained. However, it was found that, at least at present, it is not economically feasible for the casein to be made on the farms.

(*Continued on page 18*)

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BRIEFING THE NEWS

HOUSES ON THE ASSEMBLY LINE

While scientific dreams of plastic houses are still nursed in the laboratory, structural prefabrication on a commercial scale has actually been accomplished. Using synthetic resin-bonded plywood as the basic material, defense housing projects by the score have mushroomed with prefabricated house parts. One manufacturer has developed a system of resin bonding these panelled parts together by a special type of joint into a composite wallboard. Resin-bonded joints develop 80 per cent of the strength of the plywood and make possible wall coverings of practically any length.

It takes about 35 pounds of dry thermosetting resin per 1,000 square feet of veneer to bond the plywood and another 2½ pounds per 1,000 square feet to glue the panels together into a continuous wallboard. About 30 pounds of resin per 1,000 square feet attach the cotton cloth.

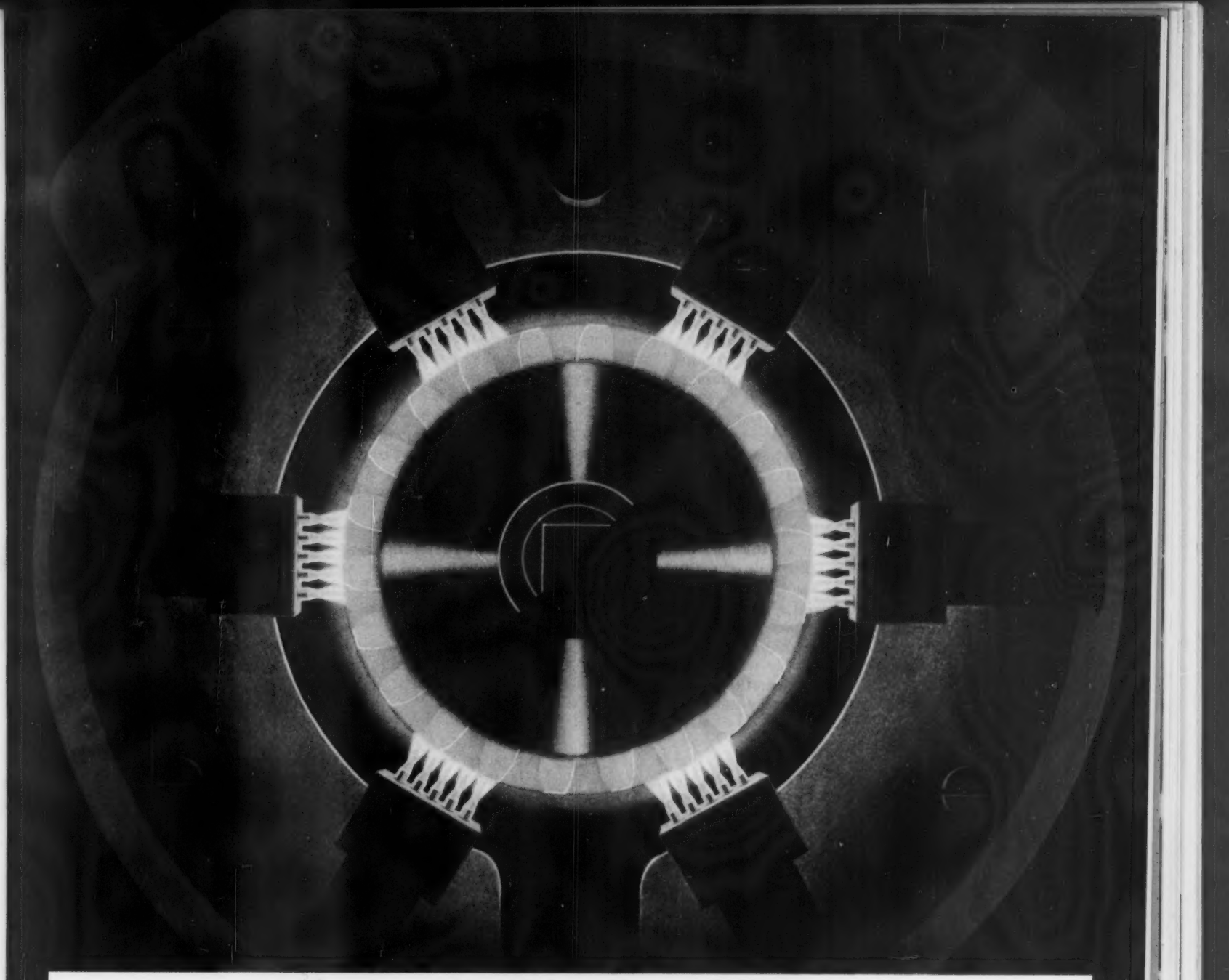
The manufacturing process begins with the making of the joints which lock the 3-ply 5/16 foot panels into continuous lengths. These jointed panels are "welded" by the use of synthetic resin adhesive, then cooled by a refrigeration unit and smoothed down under sanders. The final operation of the assembly line is the "cut-off," which eliminates all joint making on the actual job of erecting the house.

Defense work involves the prefabrication of plywood faced "stressed cover" double wall units where large wall panels are welded permanently with resin adhesive to the studs in a hot press. Resin bonds the entire contacting surface of the studs, displacing nails and producing a union of greater area and resistance to deformation. In this manner exterior and interior face panels became part of the load-carrying factor in the wall. Door and window units, with their proper frames, are similarly fabricated. One company has recently completed prefabricated walls for 150 buildings in a USHA Defense Housing project.

Digested from "Modern Plastics," December, 1941.

CONTRAROTATION AIRSCREWS

Single engine aircraft have long been subject to the rolling movement created by the rotation of the single propeller, and consequently have been affected by many erratic forces which designers have had to eliminate as best they could. In the past it has been the practice to balance out these forces by designing lifting surfaces with suitable aerodynamic couples. However, a change in conditions, engine speed for instance, will change the forces, and the unbalanced forces proceed to cause the pilot navigational troubles, and make really accurate flight difficult. The moment during which an aerial engagement begins places emphasis on accuracy of flight; it follows that our planes should be equipped as speedily as possible with some sort of mechanism capa-



A SHORTER WAY TO LONGER LIFE

Spinning furiously in a bath of fire, gears that will play a vital part in the nation's production are given longer, more useful, more productive life . . . in a hurry. Through the swift magic of the oxy-acetylene flame, not only gears, but a host of other metal parts and articles can have their wearing surfaces hardened . . . exactly where hardness is needed to resist wear.

This is something *new* in metal working. The secret of it is that heat is applied so quickly and with such precise control . . . and quenching follows so rapidly . . . that any piece so treated has no chance to become hardened all the way through. This means that valuable properties like toughness and ductility are retained in the core of the metal.

The advantages of oxy-acetylene flame-hardening are manifold. By its use, hardening can be localized to those areas where wear will occur. Thus one section of a shaft, or the rim of a wheel, or the teeth of a gear can be hardened, leaving the rest of the piece in its original condition for needed properties or easy working. Cheaper and more plentiful ferrous metals can often be made to do the work of less readily obtainable steels.

The method is lightning fast, so it saves on operating expenses. Some pieces can be hardened in as little as five seconds. Production is speeded up as costs go down. In many cases, machines can be simplified in construction by the use of flame-hardened parts.

Materials which can be flame-hardened include dozens of plain carbon, chromium, manganese, nickel, chromium-nickel, chromium-molybdenum and chromium-vanadium steels. High strength cast iron and pearlitic malleable iron can also be hardened by this method.

Linde supplies the oxy-acetylene equipment, also the oxygen and acetylene for use in the flame-hardening process. Inquiries about oxy-acetylene flame-hardening, flame-cutting, fabricating, and treating of metals are cordially invited.

• • •

The important developments in flame-hardening – and other processes and methods for producing, fabricating, and treating metals – which have been made by The Linde Air Products Company were greatly facilitated by collaboration with Union Carbide and Carbon Research Laboratories, Inc., and by the metallurgical experience of Electro Metallurgical Company and Haynes Stellite Company – all Units of Union Carbide and Carbon Corporation.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

UCC

GENERAL OFFICES: *New York, N. Y.* OFFICES IN PRINCIPAL CITIES

PHOSPHORUS AND THE PHOSPHATES

(*Continued from page 6*)

subsequent "crocking." The presence of tetrasodium pyrophosphate tends to prevent this deposition and insures a clean dyeing action.

In degumming silks tetrasodium pyrophosphate is an adjunct of exceptional merit. Its value lies in the fact that it buffers the alkalinity of the soap solution and has an effective peptizing action on suspended solids. Its use results in improved degumming, more uniform dyeing subsequent to degumming, and elimination of chafe marks, scum and streaks.

Related to the uses of tetrasodium pyrophosphate in textiles is its rapidly expanding use in industrial and household soaps. Such "built" soaps, with other alkalis such as trisodium phosphate or silicates added, are of great benefit in hard water areas. In effect, built soaps carry with them their own water softening agent so that the effect of hard waters is minimized. But the results of such additions reach further in that the additive improves the emulsifying and dirt loosening properties of soap without increasing its alkalinity. The development of tetrasodium pyrophosphate for use in soaps represents one of the prime achievements of the last ten years in industrial chemistry.

The same dispersing effect that makes tetrasodium pyrophosphate a valuable detergent is the basis of its use in the petroleum industry where it is used in preparing muds for well drilling, the tetrasodium pyrophosphate reducing the viscosity of the mixture.

Foodstuffs

The phosphate family is of diverse importance in the manufacture and preparation of foodstuffs. Phosphoric acid is used in three important ways. In sugar refining, the acid is used with lime as a clarifying agent. Raw sugar syrup contains amounts of albuminous and other protein matter. When lime and phosphoric acid are added they react to form an insoluble calcium phosphate which precipitates out carrying with it the protein impurities.

In gelatins, phosphoric acid is added as jelling agent. In this case, as well as in jellies, it functions in controlling the jelling action through maintenance of the pH at the required level. In jellies, as well as in soft drinks, phosphoric acid imparts a tart flavor and replaces fruit acids such as citric or tartaric.

Indirectly, phosphoric acid makes a contribution to food production in its use as an ensiling agent for green fodder crops. Through its use, it is possible to preserve green crops in silos with minimum loss in nutritional value, palatability and bulk.

Both tetrasodium pyrophosphate and disodium phosphate are used as small additions in dairy products. Through its use, it has helped make feasible the fast growing packaged cheese industry. Packaged cheese, ideally always of uniform flavor, color and consistency, must be made from natural cheeses that vary over a fairly broad range. In some cases, such cheeses when prepared tend to give off their fat, and globules of oil form on their surfaces which the addition of tetrasodium pyrophosphate tends to prevent. Disodium phosphate, used for the same purpose in cheese, is also used in prepared milk and in ice cream. Here its action is an emulsifier, tending to prevent agglomeration of solids and insure a smooth, creamy consistency.

Phosphates, particularly sodium acid pyrophosphate and monocalcium phosphate, have long been used as leavening agents. The function of any chemical leavening agent lies in its ability to react with sodium bicarbonate and release its carbon dioxide gas. The gas so released in a batter or dough, expands and aerates it, creating the porous light structure that is desirable. Baking powders consist of sodium bicarbonate, an acid-reacting material such as sodium acid pyrophosphate or monocalcium phosphate, plus a stabilizing agent or diluent such as starch. The two active ingredients are combined in such proportions to enable their complete reaction. Monocalcium phosphate has been used in baking powders since the middle of the nineteenth century.

The development of self-rising flours around the turn of the century was made possible by the availability of monocalcium phosphate leavening agents. The production of such flour has grown rapidly and today approximately eight per cent of all wheat flour milled in this country is of this type.

The accelerating current interest in improved nutrition throws the spotlight on the calcium phosphates as diet supplements. Dicalcium phosphate, for instance, supplies two important elements needed for bone formation and when used with Vitamin D concentrates makes a convenient and readily available mineral supplement. Tricalcium phosphate is of interest in the same connection.

Ferric phosphate is being used increasingly as a vehicle for fortification of foodstuffs including flour. This compound is a stable and convenient way of introducing available iron into the diet. The recent government recognition of flour and bread fortification makes likely its increased use.

An interesting use of ammonium phosphate is in yeast foods. Yeast today is grown under carefully controlled conditions, with balance in nutrients carefully maintained. Ammonium phosphate is one of the standard additions to the nutrients in such operations.

Even a brief survey of the uses of phosphorus and its derivatives demonstrate their wide applicability. Research, plus intelligent market development, plus courageous pioneering in production, assures their future.

---

ble of eliminating the torque as it is created. For this purpose our air force is being fitted out with twin propellers which rotate in opposite directions which the makers call "contrarotation airscrews."

This principle is not new, for it was used by the Italians several years ago in their record-breaking racing seaplanes.

In addition to their torque-eliminating property, contrarotation airscrews have smaller diameters for the same power of motor. This enables the engineer to design equipment which ordinarily would embody propeller tip speed approaching that of sound, an extremely inefficient design.

Further, the smaller diameter allows the designers more freedom in placing the wing armament.

At present, three firms have announced that they have completed the designs for contrarotation airscrews, Fairey, de Havilland, and Rotol. The reputation of these firms enables us to look forward with confidence to the future of this type of equipment.

Condensed from "The Engineer," September 5, 1941, and "United States Naval Institute Proceeding," November, 1941.

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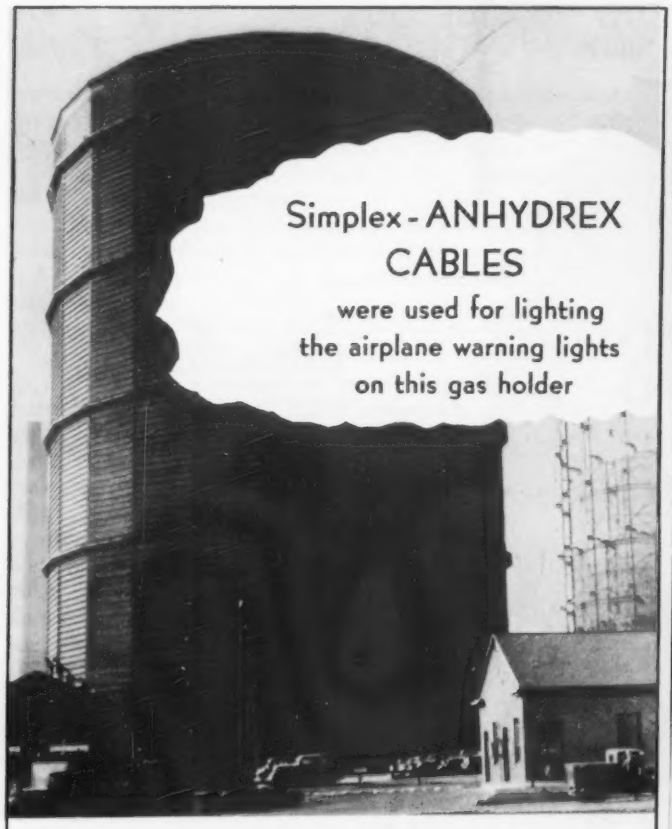

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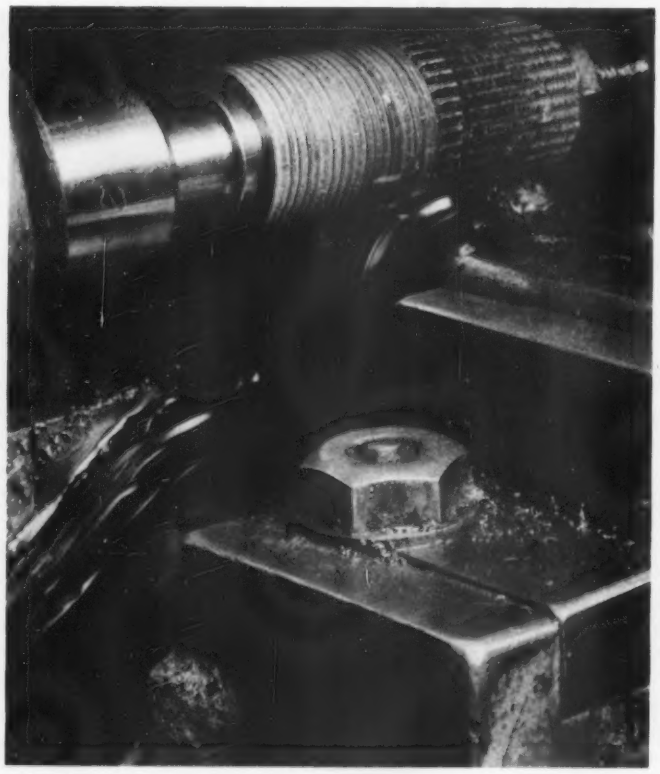
LILLIPUTIAN LOCOMOTIVES

(*Continued from page 10*)



Cutting sprocket type gears

upon both together. When the first streamlined train of the Union Pacific raced from Chicago to the coast for a speed record that thrilled the country, Lionel was already marketing a very fine scale-model of that train.

It was the Christmas season of 1937, however, that witnessed Lionel's great bid for the scale-model trade. This was done with a reproduction of the New York Central's famous Hudson-type locomotive, built to the scale of a quarter-of-an-inch to the foot and so accurately detailed as to produce a photograph in which it is indistinguishable from its prototype, a 340-ton locomotive which pulls the Twentieth Century Limited. The real locomotive cost $90,000 to build. To produce the first Lionel 21-inch model of it, the Lionel Corporation took two years' time and spent $60,000.

In mass production, the models were turned out to retail for $75 in a market accustomed to pay as much as $400 for less accurate and obviously cruder jobs. That was the beginning of a new day for model railroaders. Prices fell all around. The Lionel Hudson model was followed by a smaller model of the same locomotive, for 00-gauge track, which is little more than half as wide as the normal 0-gauge track on which most trains operate.

And then came model after model, reproductions of particular locomotives and cars in actual service on the real railroads, but always turned out by mass-production methods. (*Continued on page 24*)

Science Shoulders Arms

What science in the past has done for peacetime America needs no recounting.

But science today tackles a grimmer job. Research now must give America at war the fighting weapons she needs.

That's why Westinghouse Research Engineers—working in one of the world's leading laboratories—are devoting their full time to the nation's defense requirements.

We wish we could tell you about some of the remarkable things they've done already.

We shall—later.

Ever since its inception, Westinghouse has sought out and trained engineering talent, encouraged engineers to develop and work out new ideas, made itself an engineer's company. We're proud of the way our engineers have adapted themselves to creating and producing wartime equipment.

Westinghouse

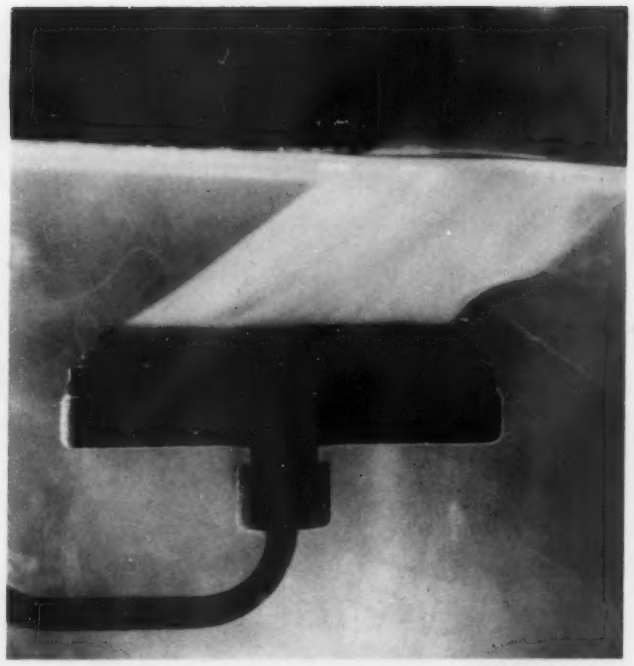
"An Engineer's Company," Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.

MILK-MADE MUSLIN

(*Continued from page 11*)

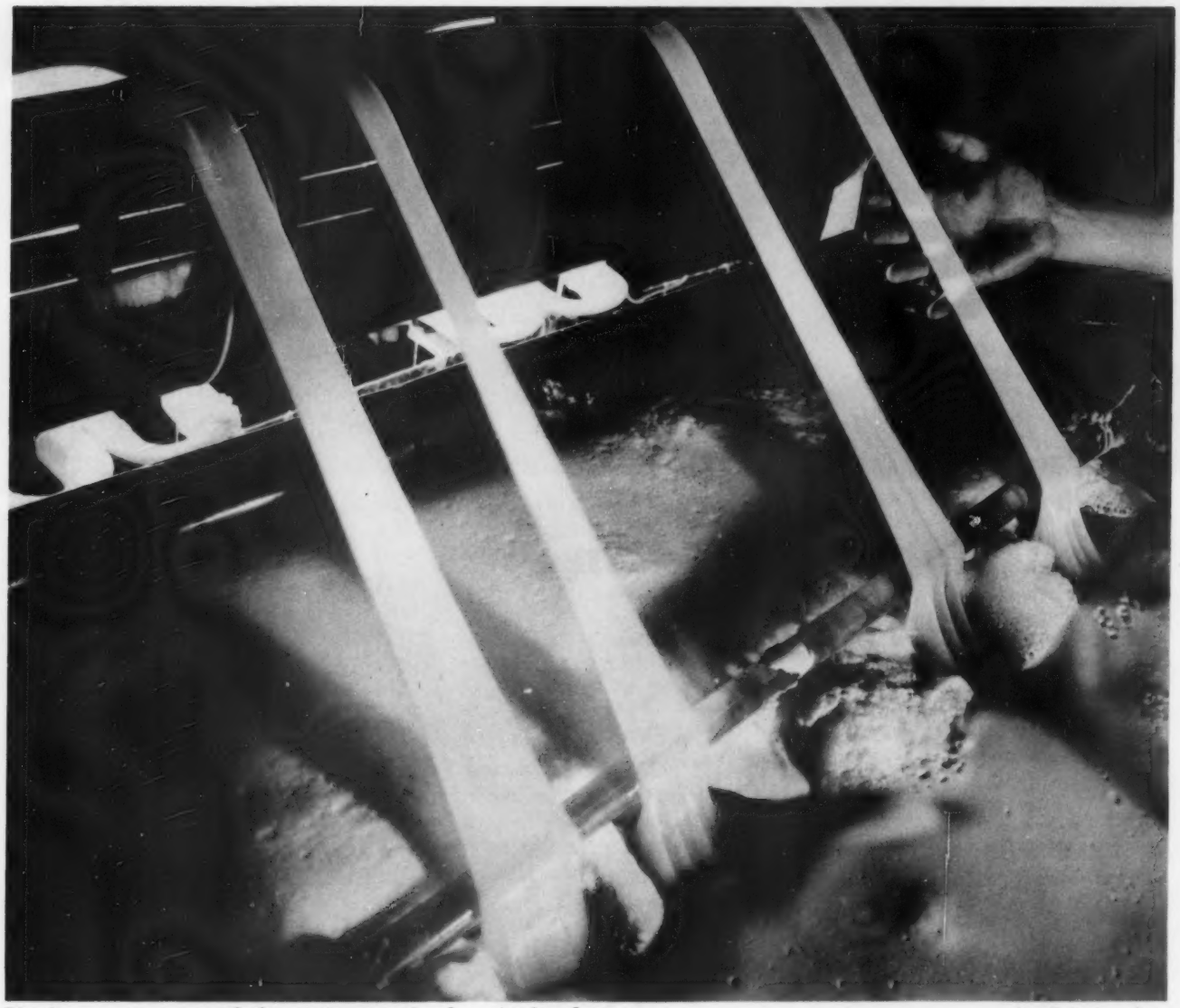
Presupposing now that it is possible to obtain the casein necessary for the manufacture of this new fiber, "Aralac" has been hailed by the textile industry as an important advancement in synthetic fiber. "Aralac" can be blended with almost every other fiber used in the textile industry and furnishes as much body or substance as fur or wool. It has excellent qualities as regards strength, resiliency, abrasion resistance, odor, affinity to dyes and the ability to withstand dry cleaning and washing. It can be blended particularly nicely with rayon and the result is a new fabric of extreme beauty and a soft resilient quality. It should not be long until almost all the clothes that we wear contain "Aralac" in some form or another.

To make this fiber it is necessary to dry and grind the casein until it is approximately the size of grains of rice. It is then treated with various organic chemicals and heated, and assumes a viscous, honey-like consistency. This mass is forced through minute spinnerets under hydrostatic pressure and emerges as thousands of small strands called "wet-tow." This "wet-tow" is treated chemically and the result is Aralac. This fiber can be made in almost any length from half an inch to half a mile and woven the same as another fiber.



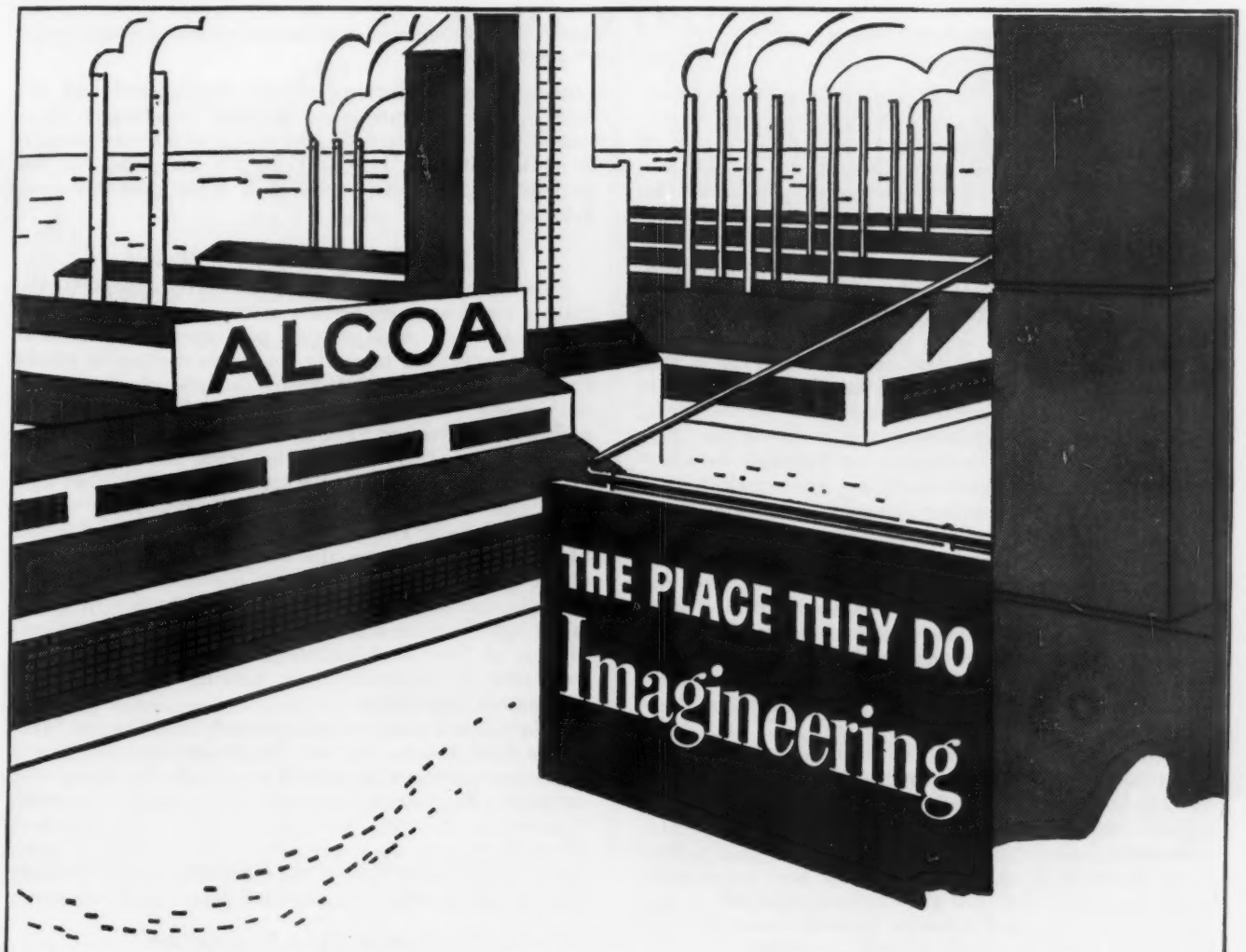
Nat. Dairy Prod. Corp

Spinneret through which casein is converted into fiber



The foamy mass conceals four spinnerets in the spinning box

Nat. Dairy Prod. Corp.



For a long time we've sought a word to describe what we all work at hard here at Alcoa.

It takes a very special word to describe making aluminum cheap, making it versatile, finding totally new places to use it, and then helping people use it where they should. In war times it takes a very special word indeed to describe, also, the ingenuity and daring that can make, almost overnight, three and four and five times as much aluminum as was ever made before, and make it cheaper than ever.

IMAGINEERING is the word. What aluminum did for civilians, what aluminum is doing for our armed forces, what aluminum will do in the future, all come out of that one word.

Imagineering is letting your imagination soar, and then engineering it down to earth. At Alcoa we have engineers with almost every kind of diploma, scientists with almost every "key" we know. Yet whatever career they follow with us, their real field is Imagineering. They work at it hard. They get results. The importance of aluminum is their own doing.

We at Alcoa would like nothing better than that our company be known everywhere as the place they do Imagineering.

ONE PAGE FROM THE AUTOBIOGRAPHY OF

ALCOA ALUMINUM

• This message is printed by Aluminum Company of America to help people to understand *what we do* and *what sort of men* make aluminum grow in usefulness.

BENEFICENT KILLER

(*Continued from page 7*)

careful aseptic measures in the Duke Hospital 206 of 1735 patients that underwent normal operations later contracted unexplainable wound infections, and 19 of them died. Determined to banish the cause of infection, Hart resorted to extremes in aseptic preparation. The infection rate of 11.9 per cent stayed about the same. There seemed to be only one logical explanation: Infectious organisms were being carried into open wounds by ventilating air, or perhaps surgeons themselves were breathing dormant or unsuspected potential death into incisions.

To confirm his belief, Hart started on a quest that lasted five years and took him into operating rooms in almost every State. Working with tireless perseverance, he made thousands of bacterial counts in samples of air taken before, during, and after operations. In every case he found confirmation of his theory that most post-operative infections are caused by air-borne organisms that are uncontrollable by ordinary aseptic technique, and at the end of his microbe hunt he, too, believed ultraviolet radiation to be the most practical weapon with which to combat this impalpable destroyer.

Failing to find a suitable source of bactericidal ultraviolet, Hart went to the Westinghouse Lamp Division research laboratories in Bloomfield, N. J. to interest scientists there in his problem — and again coincidence played an important role. Dr. Harvey C. Rentschler, director of the laboratories, with an assistant had just developed a device they called the Sterilamp, a tubular mercury-vapor ultraviolet generator that produces only 10 per cent visible light and 90 per cent invisible ultraviolet at a specific bactericidal wave length. Nobody knew then, only six years ago, just how much ultraviolet was needed to kill a bacterium, whether all bacteria react alike, and whether bacteria must be killed or merely injured to render them impotent.

Rentschler went to Duke Hospital, made bacterial counts, tested his Sterilamp somewhat apprehensively for germ-killing power, for erythema (sun-burning), and for its effect upon the eyes, then arranged eight Sterilamps in a square, circumscribing the light source over the operating table. Success was immediate. Severe post-operative infections almost disappeared and the total number of infections declined amazingly. Hart recently reported that the percentage of infected wounds at Duke fell from 11.9 to 0.24 per cent, and not one patient in 2463 cases has died from post-operative infection.

Other Medical Uses Being Studied

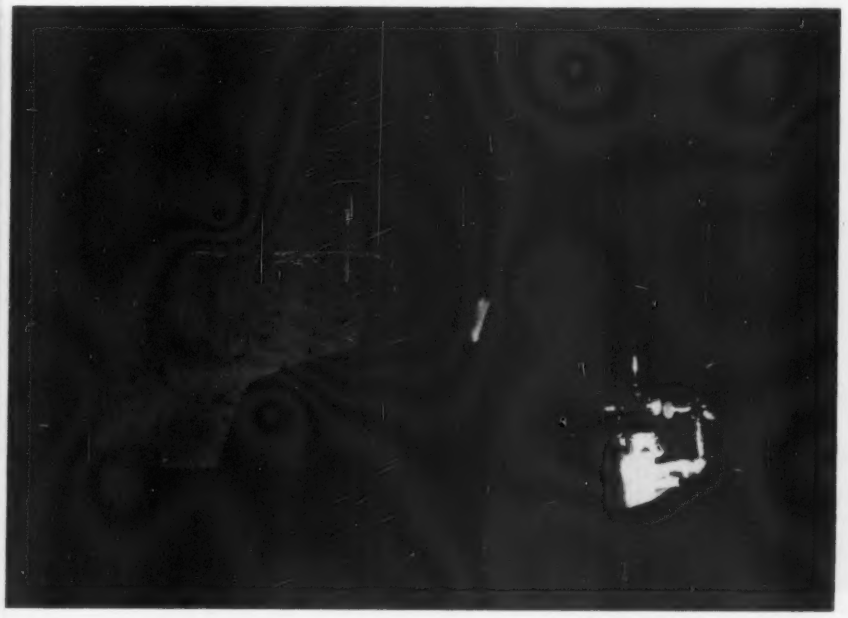
Because of the success of Hart and others, physicians now almost universally acknowledge the value of ultraviolet as a preventive of post-operative infection, and are beginning to study its use in contagion wards. Prevention of "cross infection" in these places is beset with many obstacles, not all of which are under control of the physician. For example, during an epidemic of measles a child with scarlet fever might be placed inadvertently in the same ward with several other children, thereby exposing them to a much more serious disease. Several hospitals now throw barriers of invisible ultraviolet between the beds in contagion wards to check such "cross infection." Results are promising but not conclusive. By irradiating only the air above adult eye level in a children's contagion ward, three doctors at New York's Home for Hebrew Infants have succeeded in approximately halving the number of respiratory infections.

Hart found that surgical wounds made under Sterilamps heal faster. He has not determined whether it is because of some beneficial power of the ultraviolet, or merely because it "cleanses" the wound. Columbia University research workers confirm this beneficial effect, but have discovered that an overdose of ultraviolet on an open wound may actually retard healing. This is still an almost unexplored phase of the research.

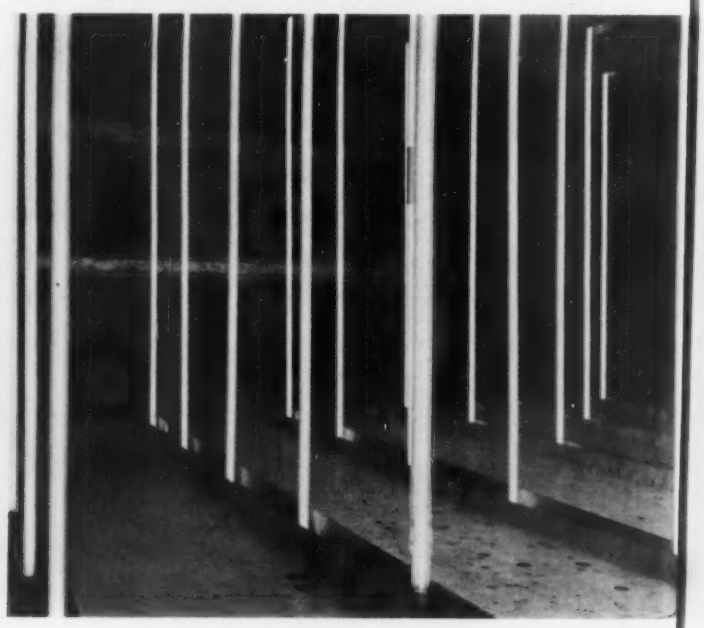
Bacteria Have Personalities

Behind these dramatic forays upon invisible killers is a parallel epic of exacting scientific research that would require pages to tell. Westinghouse's Dr. Rentschler found it much easier to devise a source of ultraviolet than to find out how to use it intelligently. He found himself without instruments for measuring ultra-

Micro-blitzkrieg in action



Sterilamp arrangement inside air duct



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violet; bacteriologists could tell him little about how bacteria react to it.

One man can thrive on a daily diet of perhaps half an ounce of narcotic drugs; the same amount would kill another. In the same way, do different races and strains of bacteria have different degrees of immunity against the lethal rays of ultraviolet? Must bacteria be killed outright to make them harmless? Or can they be put out of action by crippling them? Rentschler did not know. He was alone, trying to kill invisible beings with an invisible weapon of unknown size. To him, the way to find the answers to his question was clear; Rentschler the physicist became Rentschler the bacteriologist.

He built measuring instruments; studied the traits and habits of bacteria in endless variety; worked out improved methods of growing uniform bacterial cultures. Then he really went to work, and after almost ten years he drew some conclusions that professional bacteriologists applauded.

For example, he found that E. Coli (bacteria that live in intestines of humans and animals and are used as the "guinea pigs" of bacteriology) are not equally resistant to ultraviolet. Radiation that kills every individual of one strain may kill only three out of four of another strain. This trait is hereditary.

A bacterium, Rentschler found, may be five times as susceptible to irradiation at some times during its life cycle as at others. One that has been injured but not killed by ultraviolet takes longer to subdivide and produces "sickly" offspring, which, in turn, take onger to reproduce for several generations.

War on the Limbo of Viruses

Rentschler now seeks new invisible worlds to conquer. It seems that with sufficient experience medical research people will succeed in some measure in controlling the spread of many bacterial infections with ultraviolet. But the almost unknown viruses take a staggering toll of life in persons, in plants, and in animals, and Rentschler is just beginning to study the possibility of controlling them with radiation.

Viruses are exceedingly tiny things that cause influenza, the common cold, yellow fever, smallpox, infantile paralysis, and scores of other deadly diseases. Nobody has ever seen a virus, because they are too small to be detected with ordinary optical microscopes. With an electron microscope, shadow pictures of viruses have been taken. But viruses do not move; in fact, scientists are not sure whether viruses are dead or alive. Under most conditions they act like pure chemicals and may exist in crystalline form, but given the proper host they "come to life," thrive, and multiply. How one is to tell whether ultraviolet paralyzes a virus is a little puzzling.

Rentschler likes to be asked about this. He grins and recites a bit of doggerel:

"Great fleas have little fleas upon their backs to bite 'em,
And little fleas have lesser fleas and so ad infinitum."

Then he startles you by announcing calmly that he uses bacteria as hosts for viruses (or technically *bacteriophage*, considered by many to be true viruses). The

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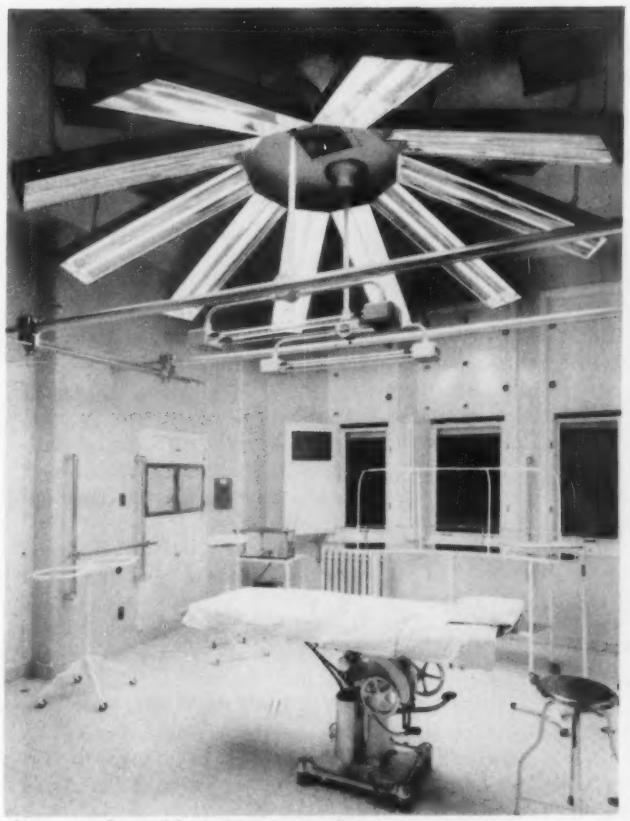
particular virus under observation is *staphylococcus bacteriophage*, a type that does not attack humans. It thrives on the *staphylococcus* bacterium (which causes boils and other skin infections), but no other known plant or animal. The method of determining the action of ultraviolet radiation is somewhat roundabout. A culture of *staphylococcus* is grown in a test tube, and as it flourishes the culture medium becomes cloudy. Bacteriophage introduced into the murky growth immediately attacks the bacteria and the tube clears. If the tube is not cleared by a viruliferous solution that has been irradiated with ultraviolet, it seems logical to conclude that the virus is no longer potent.

Experimentally it is not just as simple as that. Rentschler points out that chance plays a large part in such a test, for he has no idea of the number of phage particles that go into a given bacteria-infested tube. Individual drops of solution may contain one active particle, or a million. They cannot be counted in an electron microscope because the electron beam probably would destroy their potency as quickly and surely as ultraviolet rays. So the only scientifically accurate approach is to make thousands of tests until observed results can no longer be attributed to chance. It takes ninety-six hours to grow and then destroy a single *staphylococcus* culture; consequently Rentschler and his staff anticipate years of hard, painstaking labor before they can hope for conclusive evidence of the virucidal value of ultraviolet.

In the meantime, the Sterilamp has long since put on its overalls and gone to work. It is being used in more than a score of different industries, and as a public-health control.



Air over the table is kept pure by germicidal ultraviolet radiation *Westinghouse*

How to Slice a Meteorite!

Ever see a shooting star? There are about 7,500,000 every night! Most of them burn up in the outer atmosphere, and the few that reach the earth are man's only material link with celestial space. For examination and study, these hard, dense meteorites are easily sliced with a special type of bandsaw using Carborundum Brand Abrasive Grain as cutting agent, then finished with finer grain and powders.

Interesting, too, are the many industrial uses for Carborundum-made abrasive grains. They help polish and finish countless products, from cutlery to plowshares, from the bevelling of glass to the lapping of transmission gears and the grinding of optical lenses.

Whatever may be the use of grinding wheels, coated abrasives and other abrasive products in the industry you enter, you'll find our outstanding research, manufacturing and engineering facilities can render a real service. Write The Carborundum Company, Niagara Falls, New York.

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LILLIPUTIAN LOCOMOTIVES

(*Continued from page 16*)

By mass-production methods, too, the sturdy and colorful trains for the youngsters continue to be produced. There is a continuity there of which the Lionel Company is proud, for the millions of established Lionel customers were not forgotten amid the new enthusiasm. Lionel railroads in existence for thirty or thirty-five years can still acquire the equipment they need, whether it be in the form of rolling stock or wayside accessories.

But in the normal development of these trains it is noticed that cars and locomotives alike have in the past three years come closer and closer to scale while retaining technical features which link them to the long line of Lionel trains reaching back for a full forty year.

Meanwhile, accessories of every kind continue to pour forth under the belt line production system — stations that light up; signals that flash red and stop the approaching train, then turn to green and restart the train; grade-crossing gates that lower themselves at the train's approach and rise again when the train has passed; a crossing watchman who emerged from his shanty with warning light in addition to all kinds of cars and other railroad equipment. Over the years this list has risen till the individual items produced by Lionel for the 1941 trade aggregated 329.

A huge number are automatic or operable by remote control — operable, that is to say, by the mere pressing of buttons. Among the new things the last Christmas season were:

1. The bascule bridge, which is also a quarter-inch scale reproduction, is operable by remote control; by the mere pressing of a button it is made to open or close. It moves with a slow, powerful motion — at "scale" speed — and it automatically stops all approaching trains from the instant it begins to open till it is finally and completely closed again, whereupon it automatically restarts the trains.

2. Another item of technical equipment is an elaborate triple-action magnetic giant crane. This again is a remote control job, capable within scale limits of doing all the work of its gigantic prototype, loading and unloading cars with steel girders, pig iron, ingots, or anything normally lifted by magnetic power.

3. Also new this year is a lumber loader, which receives model logs in a chute, lifts them by a chain conveyor, and loads them into waiting cars. And the opposite number of this is a lumber car which automatically unloads its shipment of logs. Both of these are operable by remote control. They are added to a long list of other types of freight-cars which empty themselves of model barrels and model packing-cases at the touch of a button.

4. Of extreme importance to the model railroad fraternity as a whole is a new Lionel invention which permits of the operation, by remote control, of two trains on the same track, separately and independently of each other. And matching this is a second new device — a block signaling system for a two-train single-track line with only one control.

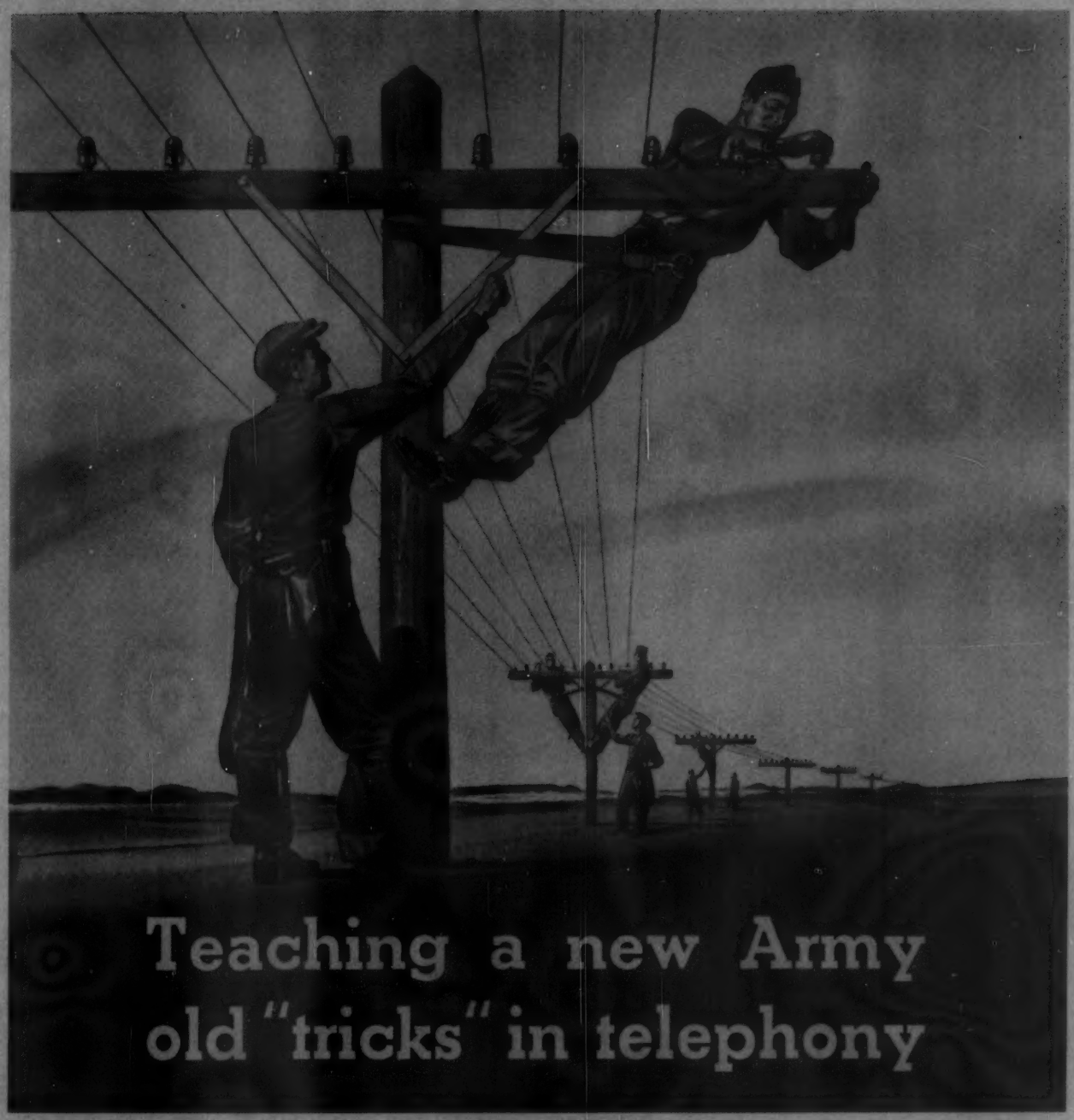
At the top of the list are the model freight-cars, each one built to the scale of a quarter of an inch to the foot, and each one flashing the name and herald of the prototype railroad company. Each, too, is equipped with automatic couplers, providing for coupling and uncoupling by remote electrical control; and each, again, is equipped with trucks which are not only equalized but sprung.

One of the cars is a Pennsylvania Railroad box-car, correctly colored and lettered, from the company's herald of keystone and monogram, straight down to the tiny stencilled notation which tells the date on which the prototype car was last painted. Another of the freight-car jobs is a Shell Oil Company tank-car; and a third is a quadruple hopper, modeled after a seventy-ton B. & O. vehicle and detailed right down to the operating spring latches. At the end of the drag is a New York Central caboose with a lighted interior and illuminated three-color markers — the colored lights carried one at either side of the last car of every train.

Among new types of wayside equipment are warning posts and signals of every description; an automatic double-arm crossing-gate which lowers itself and flashes its tiny warning lights at the approach of any train, then raises itself when the train has passed; a set of five different scale-model railroad signs lettered black on white; an automatic tolling bell, and a grade-crossing watchman who is made to wave a warning flag by remote control.

Paint shop

Locomotive assembly



Teaching a new Army old "tricks" in telephony

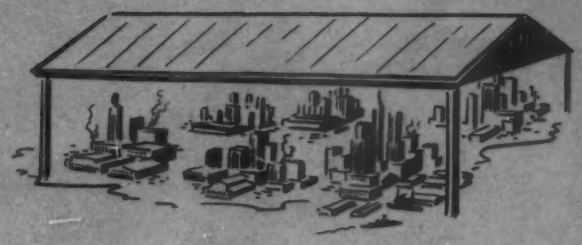
The telephone plays a vital role in army communications. So the Bell System is helping to school Signal Corps men in practically every phase of telephone construction, operation and maintenance.

This training job is but a small part of the tremendous task Bell System people are doing in this national crisis. They're setting up telephone systems for new camps, bases and factories — handling an enormous volume of calls needed to coordinate the Nation's war effort.

Throughout the country, Bell System people are wholeheartedly cooperating in the drive for victory. To men and women of their high caliber, there is real satisfaction in a difficult job well done.

BELL SYSTEM

G-E Campus News

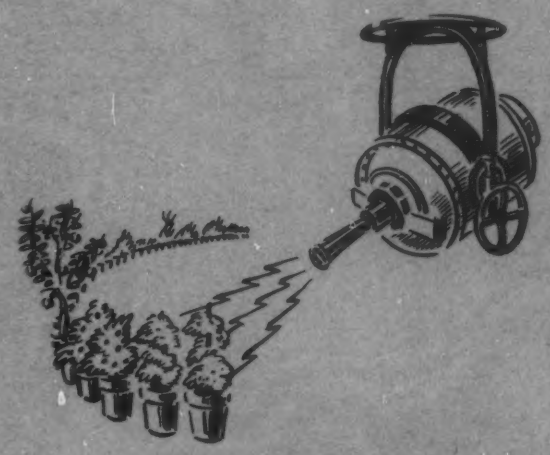


UNDER ONE ROOF

THE General Electric Company has a leased-wire communication system which functions as smoothly as if all G-E branches were housed in a single building.

During the year 1941, a total of 3796 miles was added to the leased-wire communication system to help speed the handling of contracts. A network of 11,565 miles is now available for telephone and teletype messages.

The telephone network covers 5630 miles and serves 17 key industrial cities in the East and Middle West. It contains 37 individual wires, many of which can be interconnected for greater flexibility and coverage. The teletype network comprises 4822 miles of full-time circuits and 1113 miles of part-time circuits. Thirty-one cities are served directly, and many others are served indirectly.



VOLTS AND VITAMINS

THE General Electric industrial X-ray laboratory recently moved a large number of apple and other fruit trees, berry bushes, and tomato and string bean seeds into the confines of its workrooms.

There, under an X-ray machine, these various specimens of flora were bombarded with 1,000,000-volt X rays. They were then returned to the New York State Experiment Station at Geneva for planting and subsequent observation of the effect of the X rays upon the color, size, flavor, quality, resistance to disease, and other characteristics of the fruit and vegetables.

Variations and mutations are to be expected when living plant cells are subjected to bombardment with X rays. Under forced germination, effects of the 1,000,000-volt treatment on seeds may be observed within a few days, but, for the young trees and berry bushes, the full effect will not be known for at least five years.

LE DERNIER CRI

THE General Electric Company's construction of the first large electric plant in the Belgian Congo was stalled by the lack of dowel pins, the only items missing from an inventory of hundreds of parts. The whole camp was searched, natives were questioned, but not a single dowel pin was found.

With a 90-day deadline, replacements were out of the question, so, with makeshift materials, tools, and help, new dowel pins were fashioned. The job was finished on schedule.

Months afterwards a visitor to a half-savage tribe in the Belgian Congo found men and women alike wearing a new type of nose ornament. Thrust through the cartilage of the nose, gleaming and twinkling in the African sunlight, the missing dowel pins were the pride of the natives.

GENERAL ELECTRIC

The Murray Printing Company
Kendall Square, Cambridge